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The generation and maintenance of visual mental images: Evidence from image type and aging

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Abstract

Imagery is a multi-componential process involving different mental operations. This paper addresses whether separate processes underlie the generation, maintenance and transformation of mental images or whether these cognitive processes rely on the same mental functions. We also examine the influence of age on these mental operations for independence of components. In Experiment 1, younger (22 years) and older (69 years) adults generated and maintained general, specific, contextual and autobiographical visual mental images evoked in response to concrete nouns. The older adults had longer generation times, but there was no difference between the two groups on maintenance. Both groups had shortest generation and maintenance times for general images, whereas only the older adults took longest in generating autobiographical images. In Experiment 2, the total maintenance time and number of transformations for each type of image were compared in another group of younger and older adults. General images were less transformed and more subject to decay for both groups. The older people maintained the autobiographical mental images for longest compared to other image types. In conclusion, image generation, maintenance and transformation seem to be differently affected by type of image and aging, supporting a model of their cognitive segregation.

Keywords: Mental image; Image generation; Image maintenance; Image type; Image transformation; Aging; Imagery

1. Introduction

In his pioneering investigations on mental images, Sir Francis Galton (1883) used the technique of requiring people to generate visual mental images from concrete words. During this task, various types of image are generated from the same word. Have they different functional characteristics and can they be classified into distinct categories? Cornoldi, De Beni, and Pra Baldi (1989) distinguished between general, specific and autobiographical mental images. General images represent a concept without reference to a particular example. A specific image is a representation of a single, well-defined example of a concept. Autobiographical images correspond to the representation of an autobiographical episode connected to an object. For example, the word "car" may evoke the general, prototypical shape of a car (general image); a very detailed example of a specific model of car, "the latest Chrysler Voyager 2500 TDI" (specific image); or else a particular moment in a person's life when s/he drove a car, "the first time I drove my new car" (autobiographical image). Cornoldi et al. (1989) found that participants were able to classify their images according to these three categories, and to evoke, on the experimenter's request, images belonging to only one particular category. General, specific and autobiographical images were found to differ in number of occurrences (general images being the most evoked, Experiment 1), vividness (specific images being the most vivid, Experiment 3), and generation times (the autobiographical taking longest times, Experiment 2). De Beni and Pazzaglia (1995) compared generation times of contextual, personal and autobiographical images using a similar procedure. Contextual

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images were those of objects in their usual contexts; for example, given the word “bottle”, a contextual image is that of a bottle and a number of glasses on a table. For personal images, the participants had to create *ex novo* an image of themselves interacting with the object corresponding to the given word; for example “me while I am pouring water from a bottle”. Autobiographical images required evocation of a unique episode that actually happened in the participant’s life, spatially and temporally defined, inherent in the word; for example “me while I was putting a bottle of champagne on the table during the last Christmas dinner”. At the end of the image-generation task, participants had to recall all the words contained in the lists. The results showed that autobiographical images had longer generation times than other images, but that this effect was limited to the words successfully recalled.

Do these differences in cognitive-performance level associated with types of image mirror a functional distinction between their generation, maintenance and transformation? Evidence supporting such segregation is reported in Kosslyn (1994), regarding the generation process. Kosslyn defined general images as prototypical representation of an object and specific images as exemplar ones. Autobiographical images were considered a special case of specific ones. A different hemispheric specialisation has been associated with the generation of these types of image (Kosslyn, Malijkovic, Hamilton, Horowitz, & Thompson, 1995). The right hemisphere is involved in the generation of general images, whereas the left is deputed to the generation of both general and specific images. Even if both behavioural and neuroanatomical data support the distinction between different types of image, few studies to date have measured the mental-image-generation process as a function of age and image type. Moreover, even fewer studies have investigated the role of age and image type on maintenance and transformation processes.

Another question not yet adequately addressed is whether generation and maintenance are distinct functions or else part of the same process. Kosslyn (1994) defined imagery as a multi-componential rather than unitary process, composed of image generation, transformation, maintenance and scanning, where image generation and maintenance are considered to be parts of the same process while image transformation is defined as a special case of image generation. However, this does not necessarily imply that the two processes of generation and maintenance are assimilated. In fact, results of a number of studies provide evidence of the mutual independence of generation and maintenance processes, showing that they are characterized by distinct mechanisms (Cocude & Denis, 1986, 1988; Farah, 1989; Uhl et al., 1990). Farah (1989) found that generation of mental images from memory depended primarily on structures in the posterior left hemisphere, whereas rotation of mental images depended primarily on structures in the posterior right hemisphere. Uhl et al. (1990) found that the frontal brain was activated during image generation when different parts of an image were integrated. In contrast, the frontal activity decreased during image maintenance, while the retrorolandic, posterior, temporal and occipital regions were activated. These data suggested mutual independence of generation and maintenance processes.

It was found possible to obtain further evidence supporting this distinction by individuating factors, such as characteristics of materials and of participants, which have different effects on generation and maintenance. Cocude and Denis (1986, 1988) found that high-imagery-value words resulted in faster generation, but equal maintenance times compared to low-imagery-value words; furthermore, depressed and low spatial ability people were slower in generation than, respectively, non-depressed and high spatial ability people, but similar in maintenance times. Conversely, people trained in mental concentration had the same generation times as untrained people, but demonstrated significantly longer maintenance times (Cocude & Denis, 1988;Cocude, Charlot, & Denis, 1997).

Studies into the developmental characteristics of imagery are useful for testing differences between image generation and maintenance, and to help clarify why age sometimes, but not always, affects efficiency in mental imagery tasks. Following the assumption that the two processes are supported by different cognitive functions, they might follow different developmental trends.

Kosslyn, Margolis, Barrett, Goldknopf, and Daly (1990) compared the performance of 5-, 8- and 14-year-olds, and adults engaged in four imagery tasks, designed to study image generation, maintenance, scanning and rotation, respectively. The results demonstrated a different developmental trend of maintenance compared with the other processes. In fact, 5-year-olds had performances similar to those of older participants in maintenance, but fared worse in generation, scanning and rotation.

Dror and Kosslyn (1994) found similar results when comparing young and old people. They administered four tasks involving image generation, maintenance, scanning and rotation, to two groups of young and old people. The results showed that generation and rotation degraded earlier than maintenance and scanning.

The focus of the present study was to investigate differences between processes of generation, maintenance and transformation of mental images, using the frameworks of image type and age. Finding dissociation between these processes due to differences in image type and age would lend further support to their distinction. Two experiments were performed: in both, the two participant groups (young and old) were asked to generate and maintain general, specific, contextual and autobiographical images. They were presented with words (one a time) and for each were asked to evoke the required image type. Generation, maintenance times (Experiments 1 and 2) and image transformations (Experiment 2) were recorded.

First of all, we aimed to examine the impact of age on image generation and maintenance. Finding differences between the young and the older groups in just one of the two processes would support their mutual independence. Moreover, we examined the impact of image type on image generation and maintenance. We expected that general images, as the prototypical representation of an object, would differ from the other images in generation and maintenance times, and number of transformations.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Fifty-two participants took part in this experiment: 28 psychology undergraduates (7 males, 21 females; mean age = 22.00, SD = 1.80, age range = 20–23), and 24 older people (12 males, 12 females; mean age = 69.28, SD = 3.88, age range = 65–75) contacted at a day centre for the elderly. All older participants were in good state of health and their memory, attention, spatial and temporal orientation were also good (established by means of a short questionnaire completed by a day-centre assistant).

2.1.2. Material

The stimuli were made up of 40 two-syllable, high-imagery-value words, taken from Cornoldi (1974). All words had medium–high frequency in the Italian language (50 > use value > 5, calculated on the basis of 500,000 words). Words were randomly assigned to four lists, each composed of ten words.

2.1.3. Procedure

Participants were tested individually. The stimuli were presented on a computer screen using a MEL program (Schneider, 1988). Each participant was presented with the words belonging to the four different lists, and for each list s/he had to evoke only one type of image, specified in the instructions before administration of the list. For each word, the participant was required to evoke clear and accurate visual images. The word order was randomised. The order of lists and associated image types were balanced across participants. A training session was given. During the trial phase, participants read some general instructions about mental images. These instructions explained, using examples, what was meant by a "visual mental image". Participants were instructed to perform several imagery tasks: "Create a visual image of the window in your room: what is the colour of the curtains?" "Create a visual image of an elephant. What is the tail like?" The experimenter then explained the differences between general, specific, contextual and autobiographical images, providing some examples for each category. "A general image is a prototypical image representing a category of objects. For example the general image for 'dog' is the shape of a dog, very schematic and poorly detailed. A specific image represents a specific exemplar of dog, for example a husky, whose fur is grey and white and whose eyes are of different colours." A contextual image is a representation of an object in a normal context, for example, a dog in the garden. An episodic autobiographical image is a representation of an object which is involved in a real-life episode, and spatially and temporally defined; for example, for a dog this might be going to the dog-pound to collect a dog. After the training, the first word of the first list appeared on the screen. The participant had to press the keyboard space-bar twice: the first press indicated the generation time and was made when the requested image had been evoked ("press the bar when a clear and vivid image is present in 'your mind's eye'"); the second press measured the maintenance time and indicated when the image disappeared ("When your image starts to change and/or disappear, press the bar a second time"). Both generation and maintenance times were recorded. Participants had to press the key corresponding to number 1 to move to the next word.

2.2. Results

A 2 × 4 ANOVA (age × image) for repeated measures computed on generation times (in ms) resulted in a significant main effect of age [$F(1, 50) = 26.684$, MSE = 13606379, $p < .0001$], where the older people had longer generation times ($M = 5531$, SD = 2710) than the younger people ($M = 2881$, SD = 2509). The image-type factor was significant [$F(3, 150) = 21.680$, MSE = 1729893.7, $p < .0001$]. General images ($M = 3069$, SD = 1790) had the shortest generation times compared to specific ($M = 4003$, SD = 2346), contextualised ($M = 4264$, SD = 2548) and autobiographical ($M = 5080$, SD = 3262), ($p < .001$). Specific ($p < .001$) and contextualised ($p = .01$) images significantly differed from autobiographical images. The interaction between the factors age and image type was also significant [$F(3, 150) = 2.961$, MSE = 1729893,7, $p = .034$]. As shown in Table 1, older people showed longer generation times than the younger for all types of mental image, but the two groups showed different internal patterns, depending on type of image. In fact, the group of young people showed the only significant differences between the general images compared to all others: general images had shorter generation times than all the others. In the group of older people, as with the younger group, general images also had the shortest times, but, in contrast with the young group, the older people had a significant longest time for autobiographical images compared with specific and contextualised.

Table 1
Mean generation times and standard deviations for general, specific, contextual and autobiographical images in younger and older people (in ms) (Experiment 1)

Type of image	Younger		Older	
	Mean	SD	Mean	SD
General images	2166	1391	4123	1639
Specific images	2772	1582	5439	2296
Contextual images	3111	1730	5610	2717
Autobiographical images	3474	2773	6953	2788

The analysis of maintenance times (in ms) resulted in a significant effect of image type [$F(3,150) = 6.441$, $MSE = 2075480.6$, $p < .0001$]. General images gave shortest maintenance times ($M = 4244$, $SD = 3183$) compared with the other images, which themselves did not vary (specific: $M = 5065$, $SD = 3404$, $p < .01$; contextualised: $M = 4916$, $SD = 3132$, $p = .01$; autobiographical: $M = 5489$, $SD = 3770$, $p < .01$). Neither age [$F(1,50) = .882$, $p = .352$] nor the interaction age × image [$F(3,150) = 1.265$, $p = .288$] proved to be significant. Table 2 shows the average in maintenance times for young and old people for the four images.

In the current experiment, groups were unbalanced with respect to gender. Since gender differences might have affected the results on image generation and maintenance, we randomly selected a subset of seven females from the group of young people and performed two 2 × 4 ANOVAs, on generation and maintenance times, respectively, comparing older people with the new group of younger participants balanced for gender. The new analyses showed the same significant effects and interactions as found in analyses on the whole sample.

The correlations between generation and maintenance times within each image category were low and never significant (range from .092 to .261). In contrast, correlations between generation times of general, specific, contextual and episodic autobiographical images were always significant (see Table 3) and, similarly, correlations between maintenance times of these four types of image were always significant (see Table 4).

Table 2
Mean maintenance times and standard deviations for general, specific, contextual and autobiographical images in younger and older people (in ms) (Experiment 1)

Type of image	Younger		Older	
	Mean	SD	Mean	SD
General images	3694	2871	4884	3463
Specific images	4501	2972	5723	3806
Contextual images	4758	3368	5099	2891
Autobiographical images	5243	3448	5777	4171

Table 3
Correlation between generation times of general, specific, contextual and autobiographical images (Experiment 1)

Type of image	Specific	Contextual	Autobiographical
General	.808 *	.746*	.757*
Specific		.809*	.808*
Contextual			.692*

* $p < .0001$.

Table 4
Correlation between maintenance times of general, specific, contextual and autobiographical images (Experiment 1)

Type of image	Specific	Contextual	Autobiographical
General	.852 *	.827*	.697*
Specific		.867*	.902*
Contextual			.801*

* $p < .0001$.

2.3. Discussion

The results of Experiment 1 supported a distinction between processes implied in image generation and in maintenance. According to our expectations, age had a significant effect on generation times, the older group having longer times than the younger. Furthermore, in the old people, these were longer for autobiographical images compared with the other images, probably owing to a delay in retrieval of information from autobiographical memory, which is more impaired than other memory functions in the elderly. This result supports the idea that image generation is an active task drawing on attentive and elaborative functions typical of the frontal brain. Conversely, old and young people did not differ in maintenance times. Overall, the latter results gave more support to larger involvement of central resources in image generation than in maintenance.

Furthermore, also the patterns revealed by the correlation analysis supported the distinction between generation and maintenance processes. Mutual correlations between generation and maintenance times were always low and never significant. The lack of significant correlations between generation and maintenance times supports the independence of the two processes. In contrast, correlations between generation times of the four image types were high. Similarly, also correlations between maintenance times of the four image types were high. One interpretation of this pattern of results is that the generation of different image types shares common processes, at least partially. A similar explanation might also be valid for maintenance, even if general images were least maintained of all image types.

The present data suggested that generation and maintenance of visual mental images are impacted by age in different ways. The generation process would decline with age, while the maintenance would not be influenced by age. Furthermore, even if the generation of different images shares, to a certain extent, common processes, as indicated by their correlations (and the same is true for maintenance), a different level of performance in generation and maintenance times emerged between the image types. In older people, general images had the shortest generation and maintenance times; while autobiographical images had longest generation times.

3. Experiment 2

One problem with the results of Experiment 1 was found during the debriefing. A number of participants said they had been able to maintain the image for some time in the same format, but then it altered even though it persisted. This observation left open the issue of what happens when the original image disappears and whether the elderly people remained as good as the young when total maintenance times are computed. A second experiment was therefore carried out in order to detect image transformations during maintenance, and to study these as a function of image type and age.

Here, in comparison with Experiment 1, an additional requirement was added, where participants were asked to indicate if mental images underwent transformation during maintenance. The study aimed to verify whether the number of transformations was related to age and image type. What happened when people maintained an image previously generated? Did they have a preference to inspect it, or else to transform it?

3.1. Methods

3.1.1. Participants

Forty-four participants took part in this experiment: 24 psychology undergraduates (6 males, 18 females; mean age = 21.80, SD = 2.05, age range = 19–24); 20 old people (5 males, 15 females; mean age = 71.95, SD = 3.69, age range = 65–75) were contacted in a day centre for the elderly. All older participants were in good state of health and their memory, attention, spatial and temporal orientation were also good (established by mean of a short questionnaire completed by a day-centre assistant).

3.1.2. Material

The same words were presented as per Experiment 1, divided into four lists.

3.1.3. Procedure

The procedure applied was the same as per Experiment 1 regarding the presentation of words and generation task. Participants had to press the keyboard space-bar when the image was generated. After generation, participants were asked to press the keyboard space-bar every time they detected a change in the image. Changes were defined as modifications in colour, size, and definition of the object/s represented in the original image. Instructions given to the participants were as follows: "The object/s represented in your images may be subjected to changes. For example, an object could become smaller, or larger, or you could zoom in on it. Also colours, brightness or details could change. Every time you detect one of these changes in your image, please press the space-bar". When the image either decayed or was replaced by a completely different one, the participants had to press the key corresponding to number 1. The MEL program registered the number of transformations (number of space-bar presses, from the second to the last) and total maintenance time (from the first space-bar press to the pressing of key 1). A training session was given.

3.2. Results

The number of transformations was affected by the type of image [$F(3, 126) = 12.745$, MSE = .616, $p < .0001$]: the general images being the least transformed compared with the specific, contextual and autobiographical. The average number of transformations recorded by young and old people for each image and relative standard deviations are reported in Table 5. Neither age nor age × image proved to be significant [age: $F(1, 42) = 2.556$, MSE = 6.311, $p = .117$; age × image: $F(3, 126) = 1.366$, MSE = 0.616, $p = .256$].

Table 5
Mean number of transformations and standard deviation for general, specific, contextual and autobiographical images in younger and older people (Experiment 2)

Type of image	Younger		Older		Total	
	Mean	SD	Mean	SD	Mean	SD
General	2.37	1.53	1.83	0.52	2.12	1.20
Specific	3.53	1.70	2.52	1.49	3.07	1.67
Contextual	2.97	1.67	2.60	1.20	2.80	1.47
Autobiographical	3.21	1.37	2.69	1.44	2.97	1.41

Table 6
Mean total maintenance times and standard deviation for general, specific, contextual and autobiographical images (in seconds) in younger and older people (Experiment 2)

Type of image	Younger		Older		Total	
	Mean	SD	Mean	SD	Mean	SD
General	9.72	6.81	6.54	2.67	8.27	5.53
Specific	12.60	6.01	9.49	5.17	11.19	5.80
Contextual	12.09	5.31	10.40	6.17	11.32	5.71
Autobiographical	12.93	6.64	12.37	5.27	12.67	5.99

Analysis of the total maintenance times revealed a significant effect of the image type factor, [$F(3, 126) = 24.519$, MSE = 6.416, $p < .001$]. General and autobiographical images had shortest and longest maintenance times, respectively. Table 6 shows average maintenance times and standard deviations as a function of image type and age. The factor age was not significant, $F(1, 42) = 1.795$, MSE = 110,673, $p = .188$. The interaction age × image was significant as a trend, $F(3, 126) = 2.661$, MSE = 6.416, $p = .051$. *Post-hoc* analysis showed that both the younger and older groups had shortest maintenance times for the general images compared to the other types. However, in contrast with the younger people, the elderly showed the longest maintenance times for autobiographical images compared to the other types.

Total maintenance times and number of transformations correlated significantly for the four types of image [general ($r = .696$, $p < .001$), specific ($r = .669$, $p < .001$), contextual ($r = .613$, $p < .001$), autobiographical ($r = .503$, $p = .001$)].

3.3. Discussion

Respect to Experiment 1, which focused on generation and maintenance processes, Experiment 2 was designed to better investigate the transformation process to which undergo the different types of mental images. The trend of generation and maintenance times obtained from Experiment 2 were in line with the findings of Experiment 1, showing a significant effect of age and image type.

The procedural modifications introduced in this second experiment allowed us to establish that images were inspected and transformed during their maintenance. Interestingly, transformations were in direct relation to maintenance, as though the best way to maintain an image was to manipulate its visual characteristics during a number of small changes.

Transformations were also found to relate to the image characteristics. General images, which are prototypical representations, were the least transformed and most susceptible to decay. Total maintenance times showed that general images were maintained the shortest in both age groups, while autobiographical images were maintained longest by the older people. Maintenance times in Experiment 2 were much longer than those in Experiment 1. This difference is probably an effect of instructions: asked to count transformations, participants generated transformations that induced longer maintenance times.

Age affected neither maintenance (as already found in Experiment 1) nor transformation. The latter results support that maintenance and transformation processes share some common mechanisms and are not subject to decline with age. Transforming just-generated images could be less demanding than generating them *ex novo*.

4. General discussion

The present research has considered generation and maintenance times, and number of transformations of general, specific, contextualised and autobiographical images. In accordance with previous studies (Cornoldi et al., 1989; De Beni & Pazzaglia, 1995; Helstrup, Cornoldi, & De Beni, 1997), the current results stressed the importance of distinguishing images in different types. The data showed that performance level varies as a function of type of imagery task (generation, maintenance and transformation) as well as type of image (general, specific, contextual, autobiographical). General images had the shortest generation and maintenance times, underwent a lower number of transformations of all image types. Autobiographical images had the longest generation and maintenance times. It appears that general and autobiographical images are substantially different both from each other, and from specific and contextual images. For the general images, this could be due to the fact that they are prototypical images, with different generation processes compared with other types of image (Kosslyn, 1994). Indeed, their distinction in the generation process has been supported by a functional magnetic resonance imaging (fMRI) study carried out comparing the mental generation of general and specific images (Gardini, Cornoldi, De Beni, Bromiley, & Venneri, 2005). The results showed that general-image generation is associated with areas deputed to visuo-spatial processing and formation of gestalt-like object representations, such as the parietal and occipital associative visual areas (Lee, Mumford, Romero, & Lamme, 1998), whereas specific-image generation involves a fronto-thalamic circuit linked to attention to visual details (LaBerge, 2000).

Further neuroimaging evidence (Gardini, De Beni, Cornoldi, & Venneri, 2006), addressing the neural correlates of mental generation of specific and autobiographical images, has shown that the generation of both types of image activates a common set of neural structures involving the frontal and thalamic areas. This result has been attributed to the fact that both types of image are detailed images and thus areas related to the formation of detailed images (such as the fronto-thalamic circuit) are involved in similar ways during the two generations. The mental generation of autobiographical images alone involved left medio-temporal areas (the parahippocampal gyrus) associated with episodic memory retrieval. These findings support the special nature of autobiographical-image generation, and are in line with our results, which show time generation and maintenance patterns of autobiographical images that differ from those for the other images.

In addition, our data support a distinction between generation and maintenance processes. First of all, the two indices of generation and maintenance were not significantly correlated. In contrast, the generation times of the four images were highly correlated to each other and the same pattern of correlation was obtained for times of maintenance. Second, age had different impact on generation and maintenance. Old people showed longer generation times but equal maintenance times and number of transformations compared with the young. Several studies have previously investigated other factors assumed to affect generation times, such as visuo-spatial ability (Hoffmann, Denis, & Ziessler, 1983), imagery value and generality of words (Cocude & Denis, 1988; Hoffmann et al., 1983). Other data showed that generation times were shorter when imagers had high visuo-spatial ability (Hoffmann et al., 1983), for words with high-imagery value and denoting basic concepts (Cocude & Denis, 1988). As in Cocude and Denis (1988), we have demonstrated that the variable age has a different impact on image generation and maintenance, a result that supports their mutual independence.

The present results provide a better understanding of decline in imagery ability with aging. It is relevant that we did not find differences due to age in the ability to maintain and transform a generated image, whereas we found that old people are more impaired than young in image generation. This supports the mutual independence of the two processes and, at the same time, deepens information about differences in the generation and maintenance processes. It is plausible that generation requires retrieval of information from long-term memory, a mental operation susceptible to decline with age (Dror & Kosslyn, 1994). Furthermore, some authors (Denis, Logie, Cornoldi, De Vega, & Engelkamp, 2001) affirmed that the central executive system—the active component of working memory—is involved in image generation. Old people are usually impaired in performing tasks that require intervention of the central executive; this could explain their impairment in the generation, but not maintenance, of visual mental images. A potential problem with our results is that the different generation times between young and old people might be due to slower overall response times in the elderly. We did not take account of this in our procedure, but had we done so, we would have found longer times in the older group, not only for generation times but also for maintenance.

Another interesting result is that old people are particularly impaired in the generation of autobiographical images: for this group alone generation times were longer than for the other images. This could be related to specific difficulties found in age with episodic memory. Older adults experience increasing difficulties with memory for recently experienced events, including recently learned names, list of things to do, or narratives relating to recent activities of family and friends (Cutler & Grams, 1988; Dobbs & Rule, 1987). When old people are required to retrieve an episode of their past life in order to create an image of it, they are slower than young people. It would be interesting to analyse whether the longer times depend on difficulty in retrieving an episode or, instead, in choosing an episode adequately representative of a concept from many others that are less relevant.

Finally, the results on maintenance and transformations of different types of image have provided new knowledge on the image maintenance process. To date, the question of whether images with different features are differently maintained had not been investigated experimentally. In a study on a group of individuals familiar with mental concentration techniques, i.e., hatha yoga, Cocude and Denis (1986) found that these participants were able to maintain their images longer than a group of non-experts. However, the characteristics of the images generated by the two groups were not investigated, so we cannot know if longer maintenance times were related to differences in the feature of images evoked by the two groups. Our results have shown that maintenance was strongly dependent on type of image evoked: the less detailed (general) images were more difficult to maintain and decayed more quickly.

The results of the second experiment on image transformation provided other information on mechanisms of the maintenance process. General images, apart from being less maintained, were also those less transformed. This suggests that an image is maintained longer when it is continuously manipulated, by transformation of a number of details, changing dimension, shape or colour. This is possible only when it is, from the outset, sufficiently rich in detail, components and complexity for this process to start.

A potential criticism of the current work might be that data are entirely based on subjective experience and it is quite difficult to understand what the participants actually did when asked to generate an image, to inspect it with their "mind's eye" and to detect any transformations. However, studies on mental imagery have seen a long tradition of subjective findings that have contributed to broaden knowledge on imagery processes. The methodology adopted in the current study derives from previous studies that provided clear and coherent results on the specific effects of different factors on either image generation or maintenance (Cocude & Denis, 1988; Cocude et al., 1997). Taken overall, the previous and current findings inform about the reliability of these subjective measures and testify that they are sensitive to changes in significant psychological processes.

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